**THE CONTRIBUTION OF NEW MOBILITY TECHNOLOGIES AND SERVICES TO CLIMATE CHANGE MITIGATION AND ECONOMIC WELFARE**

 Tatiana Bruce da Silva, Sustainable Energy Systems program – Instituto Superior Técnico – Universidade de Lisboa, +351912617694, tatiana.silva@tecnico.ulisboa.pt

Patrícia Baptista, IN+ Center for Innovation, Technology and Policy Research – Instituto Superior Técnico – Universidade de Lisboa, +351218417379, patricia.baptista@tecnico.ulisboa.pt

Carlos Santos Silva, Departamento de Engenharia Mecânica – Instituto Superior Técnico – Universidade de Lisboa, +351962451813, carlos.santos.silva@tecnico.ulisboa.pt

Luan dos Santos, Departamento de Engenharia – Universidade Federal do Rio de Janeiro, +5521983757577, luansantos@macae.ufrj.br

## Overview

Human-induced climate change is one of the biggest challenges facing humankind today. The causes of global warming lie in rising greenhouse gas (GHG) emissions from anthropogenic forcings and its mitigation, through decarbonization of our societies and change in our habits, thus have become increasingly urgent. Decarbonization of transportation is considered more complex than other energy end-use sectors because existing mobility technology is highly locked in the use of fossil fuels. In addition, agents’ behavioral decisions about transportation and their impacts on energy consumption must be considered when implementing decarbonization policies. Therefore, in order to effectively decarbonize transportation, it is necessary to not only deploy carbon neutral technology and fuels, but also promote the behavioral change of agents towards more sustainable mobility products.

At the same time, mobility is also going through its own transformation. New mobility services, such as carsharing, ride hailing, and automation are having and will have a significant impact on the way transportation and energy are consumed. When properly directed and regulated, these new mobility technologies can contribute to a more efficient and sustainable use of transportation through reduction of vehicle ownership and promotion of modal shift, with consequent impacts in terms of energy consumption and greenhouse gas emissions. Moreover, through their influence on transportation consumption decisions, these new technologies will also affect users’ welfare.

This study, hence, analyzes current literature on new mobility technologies in order to assess how these innovations may contribute to changes in vehicle use and ownership as well as adoption of alternative services, with consequent impacts in terms of energy use, its associated emissions, transportation decisions, and overall economic welfare of the population. Such an analysis is important because transportation’s energy consumption derives from the behavioral decision of agents, which impacts their welfare. This way, in order to fully understand how new mobility technologies will develop in an effective way, so that they can truly contribute to climate change mitigation, all these factors must be evaluated in conjunction.

## Methods

For this study, a literature review was conducted in order to assess how new mobility technologies may contribute to changes in vehicle use and ownership as well as adoption of alternative services, with consequent impacts in terms of energy use, its associated emissions, transportation decisions, and overall economic welfare of the population. This study is the first part of a broader analysis, currently in progress, that will develop a hybrid energy system/macroeconomic model where a representative agent will make transportation and energy consumption decisions, which will affect energy demand and, consequently, energy supply, emissions, prices, and welfare. New mobility technologies will be available for agents to choose as part of the transportation sector within the energy systems model.

## Results

Analysis of the literature on new mobility technologies has yielded several results that contribute to better understand how these innovations will affect energy consumption, its associated emissions, and welfare of agents.

For carsharing, the following impacts are reported in the literature, with their extent varying according to assumptions adopted: sold vehicles or delayed or foregone vehicle purchases; increased use of alternative transportation modes (e.g., walking, biking); reduced vehicle miles/kilometers traveled (VMT/VKT); increased access and mobility for formerly carless households; reduced fuel consumption and greenhouse gas (GHG) emissions; greater environmental awareness; higher rates of electric drive vehicle ownership; lower demand for parking space. Carsharing can also be used in conjunction with public transportation to provide first- and last-kilometer travelled services or to access areas with poor public transportation coverage. Moreover, a comparisson of users of free-floating and two-way carsharing services conclude they are used differently: the former group is more likely to use the service as a complement to all modes of transportation, while the latter is more likely to use carsharing as a substitute for private car ownership. Both groups, however, reduced their vehicle ownership after joining the services (Namazu and Dowlatabadi, 2018).

Concerning ride hailing services, although the magnitude of results vary per study according to assumptions made, it is reported that: they may substitute public transit, reduce vehicle ownership, and may sometimes generate trips that would not happen otherwise, thus increasing VMT/VKT and fuel consumption (deadheading, that is, driving that takes place “before beginning and after ending a shift, to reach a passenger once a ride has been requested, and between consecutive rides”, also contribute for such (Wenzel et al., 2019)). This way, in order to mitigate any potential negative impact that ride hailing services may have on energy use and emissions, vehicles used must be as fuel efficient as possible (electric vehicles, for instance). Concerning economic impacts, this review found that ride hailing may positively impact accessibility of workers in the job market, thus enhancing economic activity (less time wasted commuting increases workers’ productivity (Haddad et al., 2019)). For a developing country, ride hailing services positivelly impacted agents’ welfare because it increased access to a safer transportation mode in areas where public transportation and walking may be risky (de Souza Silva et al., 2018).

Regarding autonomous vehicles (AVs), although full automation is not yet available for the general public, their impacts have been thoroughly studied (range of impacts varies due to assumptions): congestion falls because traffic becomes more efficient; vehicle ownership may fall because people will own less cars (the same vehicle can be used by different members of the household at different times and locations, driving itself to serve the owners’ needs). Moreover, autonomous vehicles can induce additional travel demand because of more and longer vehicle trips: underserved populations, like children, elderly and the disabled, get access to mobility previously unavailable; in addition, more trips are generated and longer distances are travelled given that the opportunity cost of being in a vehicle decreases (passengers can perform other tasks while onboard). The latter can lead to urban sprawl and other land-use changes, but such effects are still unclear (including safety, economic, public health and social equity effects of automation). Some studies, however, have tried to shed light on how autonomous vehicles may impact the economy through agents’ welfare.

New mobility technologies deployed simultaneously may also counteract for increased energy consumption of autonomous vehicles. For instance, ridesharing may contribute to reducing energy consumption in the presence of full automation depending on how many trips users share. Shared autonomous vehicle fleets could have positive impacts such as, for instance, reducing the overall number of vehicles and parking spaces. Moreover, if assumptions consider that automation leads to a more efficient public transport system, AVs could lead to a favoring of urbanization processes.

These results, however, are too sensitive to assumptions, hence the need to develop more studies to evaluate all these variables concurrently: how the employment of all new mobility technologies simultaneously may impact energy systems and the economy through transportation decisions, energy consumption, emissions, and, most importantly, the welfare of agents. Besides impacts on energy use and emissions, this analysis has also found that economic impacts of new mobility technologies, through transportation decisions, have not been fully and holistically studied. While some studies analyze impacts on productivity and on fuel and time cost elasticities, they do not consider the feedback between choosing new mobility technologies and energy use/emissions. Such an analysis can provide valuable insights for policymakers implementing climate change mitigation measures.

## Conclusions

The impacts of new mobility technologies on energy consumption and emissions have been largely studied. Nevertheless, how these new technologies will affect the welfare of agents through their transportation and energy consumption choices and, subsequently, the whole economy, has not been covered in depth. Moreover, a framework that considers all these variables together is novel in the literature. By impacting the welfare of agents, new mobility technologies may further affect productivity and economic activity. Such outcomes have yet to be measured and are under development by the authors.